Brown so appropriately terms the "reduced constituent of chlorophyll." My persistent endeavours resulted in the discovery of *protophylline*, a substance obtainable through the action of nascent hydrogen on chlorophyll solutions.[1] Some years later I discovered this substance in the living plant.[2]

The existence of a *reduced constituent of chlorophyll* may be consequently considered as a perfectly established fact, and will be probably brought to account by the chemical theory of the chlorophyll function. I conclude my French paper with the following words:—"L'étude de ces substances ne manquera pas à jetter une vive lumière sur le *coté chimique* de la fonction chlorophillienne *qui à été étudié dans ce dernier temps presque exclusivement au point de vue physique.*"

To sum up: though it may be clearly seen that for nearly thirty years I have been considering chlorophyll as a *chemical* sensitiser (or, strictly speaking, an *absorbent* of the products of dissociation of CO_2 and H_2O), still even now I must confess that this theory lacks direct experimental proof and may be considered only as a matter for further research, whereas the physical aspect of the question (*i.e.* that CO_2 and H_2O are decomposed through the agency of those rays of the spectrum, which are absorbed and somehow transformed by chlorophyll) is but the expression of a fact, put beyond any doubt by my researches, both on the decomposition of CO_2 and on the production of starch in the living plant.[3] But I do not abandon the hope that the discovery of the *protophylline* may turn out some day to be a step in the direction of a *chemical theory* of the chlorophyll function, somewhat similar to that of the colouring matter of the blood—an analogy which has been present to my mind ever since I became acquainted with the classical researches of Sir G. G. Stokes in that direction.

University, Moscow. CLEMENT TIMIRIAZEFF.

I REGRET that M. Timiriazeff should regard the concluding lines of my presidential address as doing him some injustice.

No one can be more impressed than I have been with the extreme beauty and importance of M. Timiriazeff's work, which cleared away many illusions, and for the first time prominently brought out the fact that the rays corresponding to the principal absorption band of the chlorophyll spectrum are those which are mainly active in the assimilatory process.

I have always regarded M. Timiriazeff's paper of 1885 (*Ann. des Sciences Nat.* [*Bot.*], vol. ii. p. 99) as being one of the most convincing and eloquent expositions in scientific literature, and the final proof of the proposition there laid down was given by the author in 1890 (*Compt. rend.* 110, 1346), when he succeeded in showing that the reappearance of starch in a depleted leaf exposed to a pure spectrum only takes place in the region of the red corresponding exactly to the principal absorption band of chlorophyll.

With regard to the first point raised in M. Timiriazeff's letter, I may say that when preparing my address I experienced a difficulty in ascertaining who it was that first drew attention to the existing analogy between chlorophyll and a chromatic sensitiser.

There is no complete list of Sir William Abney's papers, and knowing that he has sent many communications on this and cognate subjects to photographic journals in various parts of the world, I applied to Sir William Abney before writing what I did. There can be no doubt that chromatic sensitisers were very much "in the air" immediately after Vogel's discoveries of 1873, and it is probable that the application of these new ideas to chlorophyll occurred independently to Abney, Timiriazeff and Becquerel.

M. Timiriazeff's second objection is that I have not sufficiently taken into account his views of the function of chlorophyll as a *chemical sensitiser.* On this point I may say that I had in view his paper of 1885: "État actuel de nos connaissances sur la fonction chlorophyllienne," which it was fair to imagine fully embodied the author's view up to that date. It is certainly the *physical rôle* of chlorophyll which is there insisted upon, as the following quotation indicates: "Le rôle de la chlorophylle dans le phénomène de la décomposition de l'acide carbonique peut donc être résumé ainsi: elle absorbe les radiations qui possèdent la plus grande énergie et transmet cette énergie aux molécules de l'acide carbonique qui, à elles seules, n'éprouveraient pas de décomposition, étant transparentes pour ces radiations énergiques."

That the physical conception was certainly uppermost in M. Timiriazeff's mind at that time is further shown by the diagram and remarks immediately following, in which he regards the molecules of carbon dioxide as suffering "shipwreck" in the luminous undulations corresponding to maximum amplitude.

It is, however, quite clear from M. Timiriazeff's references to his paper of 1877, and especially to his Russian paper of 1871, neither of which I have seen, that he has expressed views which are practically identical with those contained in the concluding remarks of my address. It is to be regretted that these ideas were not again clearly brought forward in the 1885 paper, which purported to give the author's latest views on the whole question, and that the physical idea of the immediate transference of the energy of radiation was there made the dominant one.

52, Nevern Square, Kensington. HORACE T. BROWN.

A Simple Experiment on Thermal Radiation.

THE following experiment, which has been successfully performed by our students for several years, may be of interest to teachers of physics.

Three chemical thermometers are chosen of equal size and shape. The bulb of one is silvered, of the other covered with dead black paint by dipping it into a mixture of lamp-black and alcohol, whilst the third is left unchanged. For silvering, any of the well-known solutions and processes will be applicable. The thermometers indicate the same temperature if there is no source of radiation near them.

But if a gas flame, for example, an Argand burner, be placed at a distance of 20 centimetres from them, so that the thermometers, hanging from a stand, are at equal distances from the flame, the temperature rises at a different rate, and to a different, though in each thermometer constant, height. The silvered

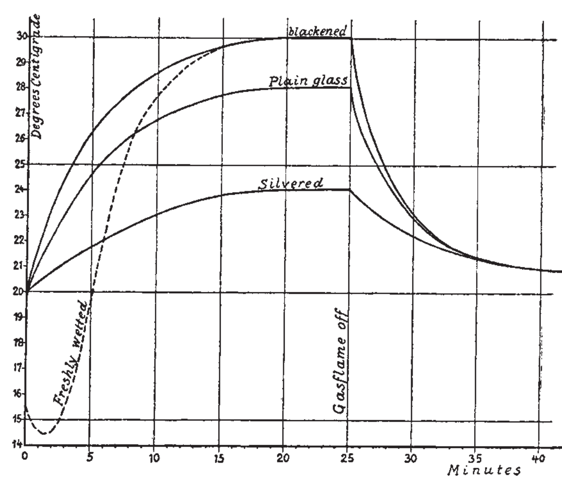

FIG. 1.

thermometer gives the lowest reading, and the blackened the highest, whilst the thread of the uncovered one stops at some point between these readings nearer to that of the blackened than the silvered; for the different surfaces of the thermometers absorb the radiation of heat generated in the flame in different proportion. The blackened thermometer bulb almost completely absorbs the rays falling on it; the silvered and polished bulb reflects the radiation reaching it; the plain glass bulb partly reflects and partly absorbs the rays. Thus, none but the silvered bulb thermometer indicates the temperature of the air communicating heat to it by conduction. As the other thermometers rise in temperature, they emit radiation; and when the amount of heat emitted from them equals the amount received through radiation from the gas flame, they are in the final stationary state, which is, of course, reached by the thermometers at different temperatures.

If the gas flame is put out, the temperatures of the three

[1] The first description of this curious substance was given in two short notes communicated to these columns: "Colourless Chlorophyll" (NATURE, 1885, p. 342) and "Chlorophyll" (NATURE, 1886, p. 52). For more ample details, see *Comptes rendus*, 1889.

[2] "La protophylline dans la plante vivante" (*Comptes rendus*, 1889).

[3] "Enregistrement photographique de la fonction chlorophyllienne par la plante vivante" (*Comptes rendus*, 1884).

thermometers fall at different rates. Observations made simultaneously on them every minute, and plotted on squared paper, illustrate fairly well Kirchhoff's law enunciating that a body emits those rays best which it absorbs best. When the gas flame is replaced by a freezing mixture, the greatest fall of temperature is experienced by the blackened thermometer, and the least by the silvered one, for the same reasons.

The same arrangement of thermometers may be used to show the cold produced by evaporation. For this purpose, the bulb to be blackened has to be wetted immediately before starting the radiation experiment. First the temperature of this thermometer falls, even though the gas flame be lighted, but after a few minutes its temperature rises very quickly to reach the same state of equilibrium as when taken with dry black paint. In Fig. 1 the dotted curve represents the behaviour of the freshly wetted blackened thermometer.

For silvering the thermometer bulbs, we use most successfully the process described first by A. Martin in *Poggendorff's Annalen* (cxx. 1863, p. 335), and reprinted in many of the books on practical physics. K. T. FISCHER.

München (Bavaria), Kgl. Technische Hochschule.

THE TOTAL ECLIPSE OF THE SUN.

THE last total solar eclipse of this century appears to have been successfully observed all along the line of totality. The weather conditions were favourable at all the observing stations, and numerous photographic and visual observations have been made of the phenomena revealed during a total eclipse. Elaborate arrangements were made to study the eclipse in all its aspects, and it has fortunately been possible to carry them out in a most satisfactory manner.

A code telegram received at the Solar Physics Observatory, South Kensington, from Sir Norman Lockyer, states:—"At the time of the eclipse the weather was excellent, and all the instruments were satisfactorily employed. There was a fall in temperature during the eclipse of from 4° to 6° C. The eclipse was not a dark one, and very few stars were seen. The corona exhibited large equatorial extensions and distinct polar tracery as expected. Observations of the shadow band were fully made in two planes. In the fixing up of the instruments, and the making of the observations, assistance was given by about 150 of the officers and crew of H.M.S. *Theseus*, which conveyed the eclipse party from Gibraltar to Santa Pola, a few miles south-west of Alicante."

The corona was similar to those observed during the eclipses of 1878 and 1889—both epochs of sunspot minimum—and thus supplies additional support to the probability of a real connection between the coronal structure and the state of solar activity. There were two long equatorial streamers, the western one being bifurcated and extending about two solar diameters. Several observers note that the inner corona was visible for at least *five* seconds after totality.

The eclipse was a short, and therefore a bright, one, which accounts for the general report that no shadow was seen either on land or in the atmosphere, and that very few stars were visible. Mercury and Venus were, however, observed. All the reports agree in estimating the duration of totality as shorter than was expected, so that the lunar tables will need slight revision for future computations.

Important observations were made of the shadow bands, which are stated to be very different in many respects from those previously observed. From one of the American stations it is reported that the bands were about one inch in breadth, their general direction being south 56½° E.; before totality their motion was at right angles to this—that is, almost north-east; and in the opposite direction after totality. Superposed on the linear bands, however, were certain dark patches previously unnoticed, having a motion at right angles to that of the bands. Baily's beads were well seen at the instants of second and third contact.

Prof. Todd, at Tripoli, is reported to have successfully employed twenty photographic cameras, one of which was furnished with a lens of 24 inches aperture.

The party at Pinehurst, from the U.S. Naval Observatory, under Prof. Skinner, obtained a good series of spectrum photographs, including five with plane and concave gratings and four with an objective prism; also five large scale photographs of the corona with a lens of forty feet focus..

Prof. Pickering obtained a good series of photographs with the new large instrument he had specially made for searching for an intra-Mercurial planet.

As we go to press, the following description of the observing parties at Santa Pola has been received from Sir Norman Lockyer.

PREPARATIONS AT SANTA POLA.

Santa Pola, Friday, May 25.

The party from the Solar Physics Observatory arrived here on May 17, and now, thanks to the assistance so freely rendered by the Spanish authorities of all grades, and the strong working parties furnished by H.M.S. *Theseus*, the instruments are all in order and we are ready for the eclipse.

At Gibraltar the Captain of the *Theseus* sent off Mr. Daniels, torpedo gunner, to meet the Expedition, and the sixty-nine cases of instruments were carefully transferred to a lighter, and so soon as they were landed here those belonging to each instrument were at once brought alongside the piers which had already been erected for them on a site as near the landing stage as possible, thanks to the diligence of Mr. Howard Payn, a volunteer assistant who had preceded the party by rail and had secured the necessary bricks at Alicante.

The prismatic cameras, and those of the ordinary kind, fed by cœlostats and siderostats, with all prisms and mirrors, were in adjustment by the 21st, and drills were begun on the 22nd.

The parties of observers are as follows; and careful notes of the arrangements made are being kept, as some improvements have been made on those adopted in 1898.

Parties on Shore.—Prismatic cameras. (1) One prism (20 ft.); (2) two prisms (7 ft. 6 in.). Coronagraphs. (3) Graham (f. 6·5); (4) Dallmeyer (f. 8·0 about); (5) De la Rue (f. 17·5); (6) long focus (f. 48). (7) Discs. (8) Shadow bands. (9) Meteorology. (10) Stars. (11) Landscape colours.

Parties on Board.—(1) Stars. (2) Shadow. (3) Meteorology. (4) Landscape.

The whole party is in robust health, thanks to the glorious climate and any amount of work in the open air. We live in a little inn, which since the Queen's birthday has blossomed into the "Victoria Hotel," kept by one Frasquito Dols, a Spanish sailor and sea-cook, a regular "handy man," who has put up mosquito curtains, and rigged up a lift to carry our well-cooked food and excellent local wine to the first floor where we reside; in rooms which, though furnished with unparalleled simplicity, are absolutely clean. It seems a pity that more do not know of this delightful climate so near home, in which the winter months may be so pleasantly spent in the shadow of date palms.

The ship is much further away from the shore than in 1898—some 2000 yards—and the winds rise very suddenly in the open roadstead. The administration of the camp, therefore, devolves upon Lieut. Doughty, R.N., who, with Lieuts. Andrews and Patrick, remain constantly on shore in a pile-dwelling—a bathing establishment which has seen better days, and has been rechristened "Theseus Villa."

The "Scotch Commission," as it is called here—that is,